Q POLAR EXPEDITIONS Q ESKIMOS Q ARCTIC WILDLIFE

ICY WATERS

Derek Fordham/Arctic Camera

Sure-footed *huskies and other sled-pulling dogs provide efficient transport across the polar regions.*

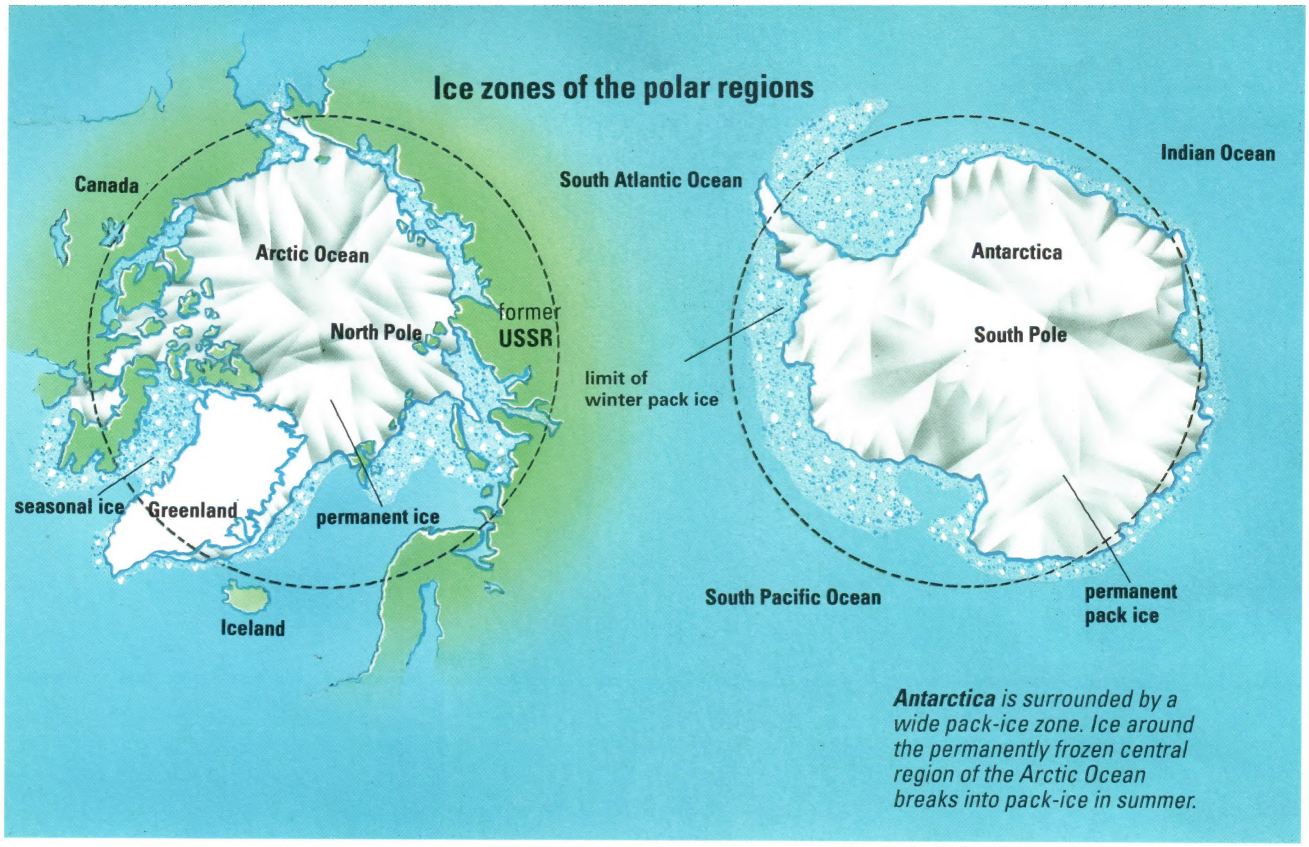
A DESOLATE BODY OF WATER and ice where temperatures rarely rise above 8° C, the Arctic Ocean, which dominates the north polar region, is a bleak and hostile environment.

Both the north and south polar regions are wildernesses of ice caps, snowstorms, and biting winds. But whereas the Antarctic has beneath its layer of ice a great continent twice the size of Australia, the Arctic is an ocean, at the north of the planet, nearly 5,300 km across, which is almost completely encircled by land

During the summer, only the central part of the Arctic is frozen. This includes the permanent pack ice around the North Pole that never melts. But, as the winter approaches, the ice cover begins to spread southwards and the entire ocean becomes locked by ice as temperatures plunge down as low as −70° C.

Because of the dissolved substances in it, seawater must be colder than pure water to freeze. Instead of freezing at 0° C, the temperature of seawater has to drop to about −2° C before it starts to turn to ice. When

Jen & Des Bartlett/Bruce Coleman Ltd



Simon Critchley

***Antarctica** is surrounded by a wide pack-ice zone. Ice around the permanently frozen central region of the Arctic Ocean breaks into pack-ice in summer.*

this happens, the dissolved substances drop from the ice to the unfrozen water below. Sea ice, therefore, is made of pure water.

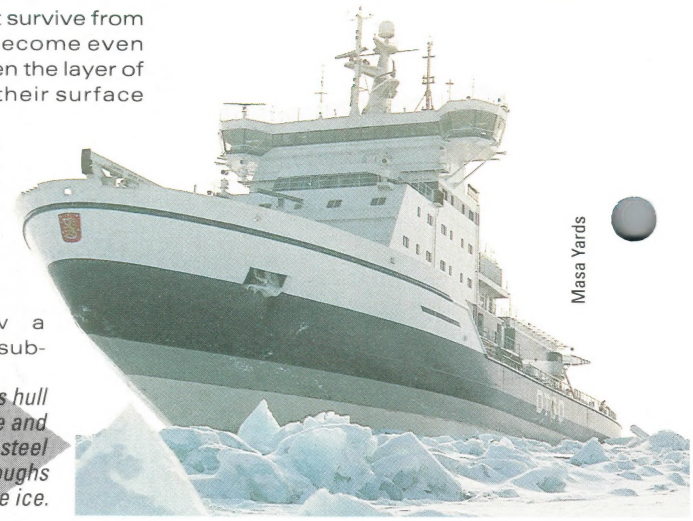
The build-up of ice on the ocean surface takes place in several stages. First, small crystals of ice form and join together forming thin platelets called pancake ice. These pancakes freeze together to create an ice shelf or floe about two to three metres thick. Any ice sheets that survive from the previous summer become even thicker and stronger when the layer of melted ice that lies on their surface freezes over again in the winter months.

Being lighter than water, sea ice floats, insulating the water below from the bitterly cold air. This means that the Arctic Ocean is always clear below a certain depth, allowing submarines to pass directly under the North Pole even in winter.

To generations of explorers who have tried to reach the North Pole, the Arctic has presented one of the most formidable obstacle courses on Earth. Blizzards lasting for days, temperatures so low that exposed skin can freeze in seconds and shifting ice underfoot are just some of the hazards they have had to face.

Most overland polar expeditions set out from the northern coast of Ellesmere Island, Canada, at around latitude 83°N. The straight-line distance from here to the North Pole is 769 km, all of which can be covered on foot or dog sled during the frozen winter and spring months.

Unfortunately, the ice is not all smooth and unbroken. Wind and undersea currents cause the ice to shear



Masa Yards

***An ice breaker,** with its hull designed for low resistance and surrounded by a stainless steel compound shell-plate, ploughs its way through the ice.*

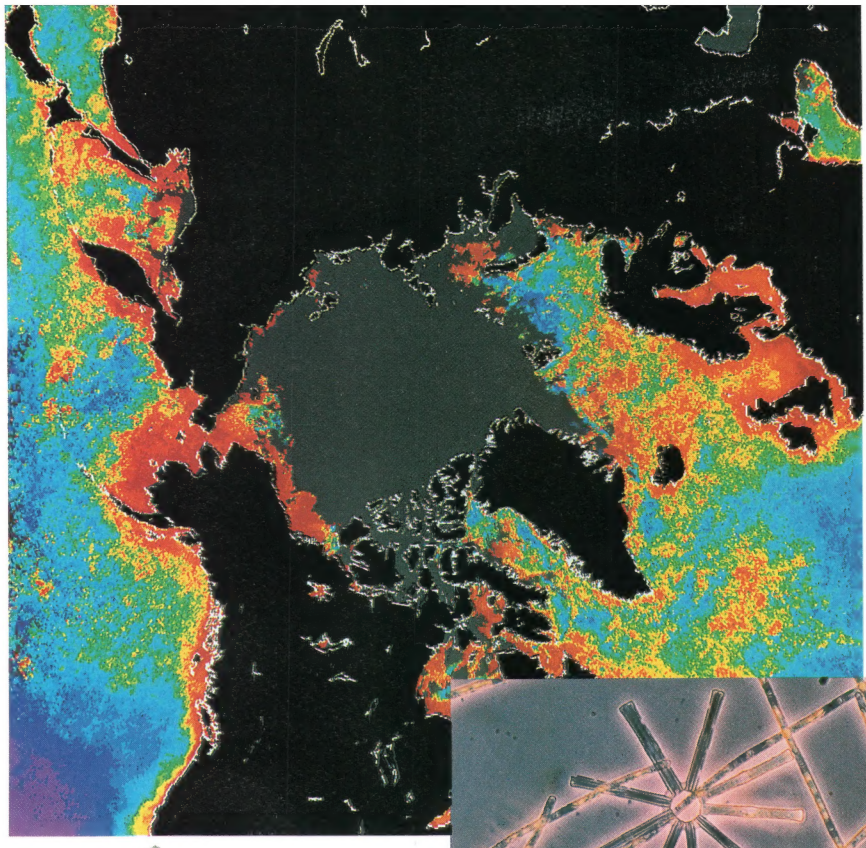
FLOATING ICE

Doug Allan/Science Photo Library

One of the most spectacular sights in polar seas, icebergs are huge chunks of ice that have broken away from glaciers – slow-moving rivers of ice, which flow down the sides of mountains in Antarctica and the lands encircling the Arctic Ocean. About 12,000 icebergs are produced by glaciers in Greenland each year. Driven by winds and currents from the Arctic into the North Atlantic, many become a hazard to shipping. Large glaciers are tracked by the International Ice Patrol and towed away if they move into shipping lanes. This organization was formed in 1913, a year after the giant liner *Titanic* struck a small iceberg and sank on its maiden voyage.

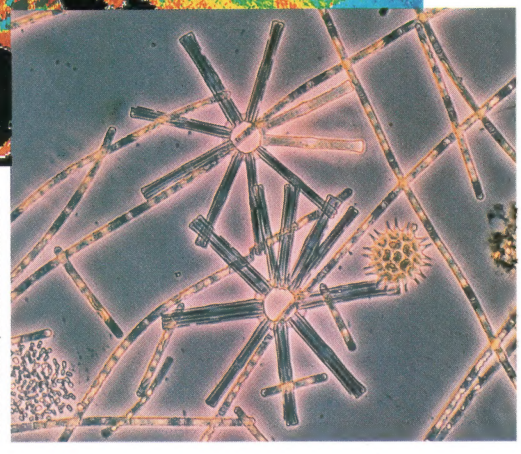
Colin Monteath/Mountain Camera

***The skidoo's low ground pressure** prevents it from sinking into snow or ice. Capable of towing loads of up to 500 kg, it has a small ski at the front and two at the back for steering, while a caterpillar track drives it forward.*



Dr Gene Feldman/NASA, GSFC/SPL

A false-colour satellite image *of the Arctic Ocean in the summer months shows the various densities of phytoplankton in the surface water.*



Frieder Sauer/Bruce Coleman Ltd

Phytoplankton *– a mass of tiny plants that drift or float passively in Arctic waters – are a vital part of the marine food chain.*

Just amazing!

DEEP FREEZER

DURING A 1986 ARCTIC EXPEDITION ANN BANCROFT FELL INTO THE OCEAN. HAVING CHANGED CLOTHES AT -30°C, SHE TOOK TWO DAYS TO WARM UP.

Paul Raymonde

and buckle. This gives rise to areas of open water known as leads and, in other places, a maze of ice rubble called a pressure ridge where two ice shelves have rammed into one another. Crossing a lead or pressure ridge is dangerous, time-consuming and extremely exhausting.

Frostbite

Temperatures of -30° C or lower pose a constant threat of frostbite and the slightest wind can cause eyelids to freeze shut. Highly insulated, layered clothing is essential, but even this becomes soaked with several kilos of sweat during a polar trek and cannot prevent at least some frostbite to the face, fingers and toes.

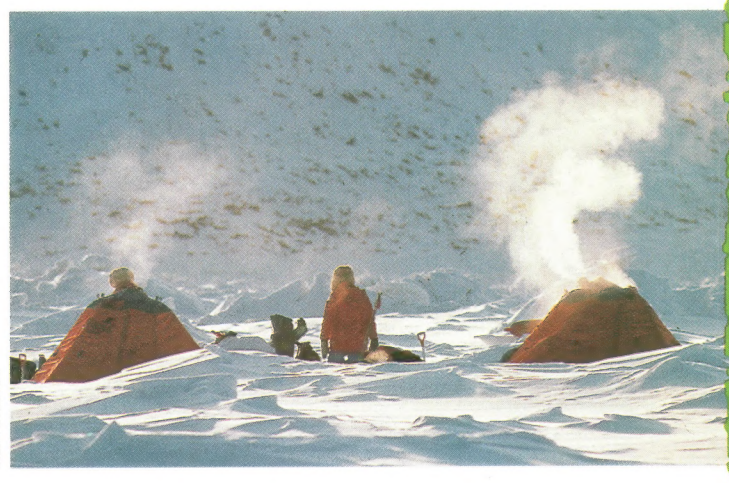
One of the main enemies of all polar expeditions is time. A team of men and dogs can only haul so much food and other supplies on their sleds. If bad weather and treacherous ice conditions delay the team by more than a few days, then the expedition may have to be abandoned.

One group of people that have fully adapted to life in the Arctic are the Eskimos, or Inuit as they are properly called. Most Inuit live north of the Arctic Circle in Greenland, Alaska, and on the northern coast of Canada. Until recently, they used cut blocks of ice to build igloos, which they heated with seal-oil lamps. They also trained dogs to pull sledges called komatiks and hunted seals, walrus, and caribou with spears and harpoons.

Today, Inuit live in wooden houses and usually travel about in pick-up trucks or motorized sledges called snowmobiles. However, they have recently been granted large areas of land of their own and now combine an up-to-date lifestyle with their own hunting traditions, culture and language.

A wide variety of animals and plants thrive in and around the Arctic waters. In summer, the Sun's rays shine almost 24 hours a day on the Arctic, stimulating the growth of trillions of microscopic plants called phytoplankton. These form the basis of a marine food chain. Animals such as shrimp-like krill feed on the phytoplankton and they in turn are eaten by larger creatures such as whales, seals, fish, and seabirds.

Thick layers of fat, feathers or fur help to insulate Arctic animals from the chilly air and sea. Walruses, for instance, have blubber that is up to 15 cm thick in places and can weigh



Rex Features

A student team *makes preparations to establish a base camp at Eureka on the Arctic Circle for the Icewalk – an eight-man expedition team to the North Pole. The aim of the expedition was to involve young people in the Icewalk call for action concerning pollution, in particular the holes in the ozone layer.*

VOYAGE UNDER ICE

The first nuclear-powered submarine to be built, the *USS Nautilus,* was also the first submarine to travel under the North Pole, in 1958. Its onboard reactor allowed it to remain under the water for several months at a time, dive as deep as 400 metres, and travel at 40 km/h. After leaving Hawaii on its historic journey, with Commander Anderson in charge, the *Nautilus* headed towards the UK by way of the Arctic Ocean. It passed directly under the North Pole at 11.15 a.m. on 3 August, 1958.

Tony Stone Photo Library, London

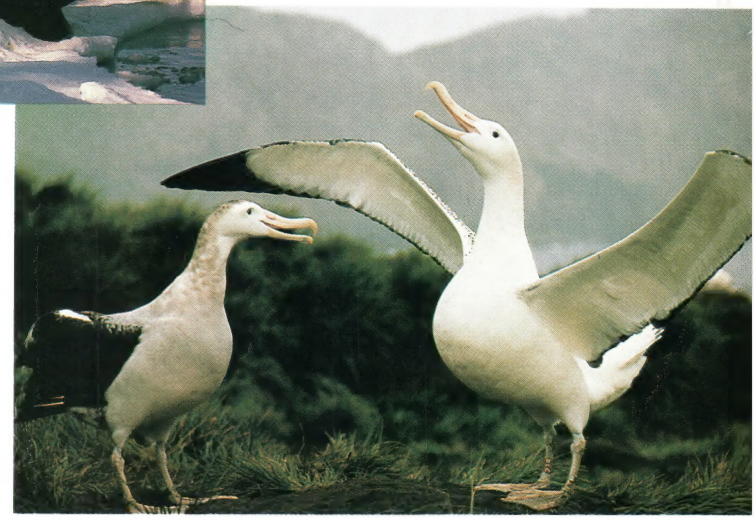
well over 400 kg by itself. An adult male may weigh up to 1,600 kg – the same as 23 fully grown men – and sport tusks one metre long. Walruses use their tusks for fighting, hauling themselves along the ice and stirring up mud on the bottom of the sea in search of the shellfish they like to eat.

Seals and young walruses are one of the favourite meals of killer whales. Sometimes two or more killer whales will work together to capture a seal that is resting on an ice floe. One whale pushes up the side of the floe while another waits with its jaws open wide to catch the seal as it slides off.

Of the land animals inhabiting the Arctic, the polar bear is by far the largest and strongest. A fully grown male may weigh up to 450 kg and measure 2.7 m in length.

Polar bears will eat almost anything, including fish, birds and their eggs, and scraps thrown out by people. One of the few tourist attractions in the little, isolated community of Churchill on Hudson Bay is the annual visit of polar bears to the town's rubbish tip. On the open ice, however, polar bears prefer seals which they stun with a swipe of their front paws and then tear apart with their teeth and claws.

A walrus's teeth *are made for a diet of molluscs. Huge canines in the upper jaw are used for digging the molluscs from the ground or scraping them off rocks. The walrus removes the shell and eats the soft parts.*



Albatrosses *during their elaborate mating ritual on special breeding islands squeal and clash their beaks together.*

Tony Stone Photo Library, London

Seals *can move about on land, but their powerful hind flippers and front steering flippers allow them to move faster and more gracefully in water.*

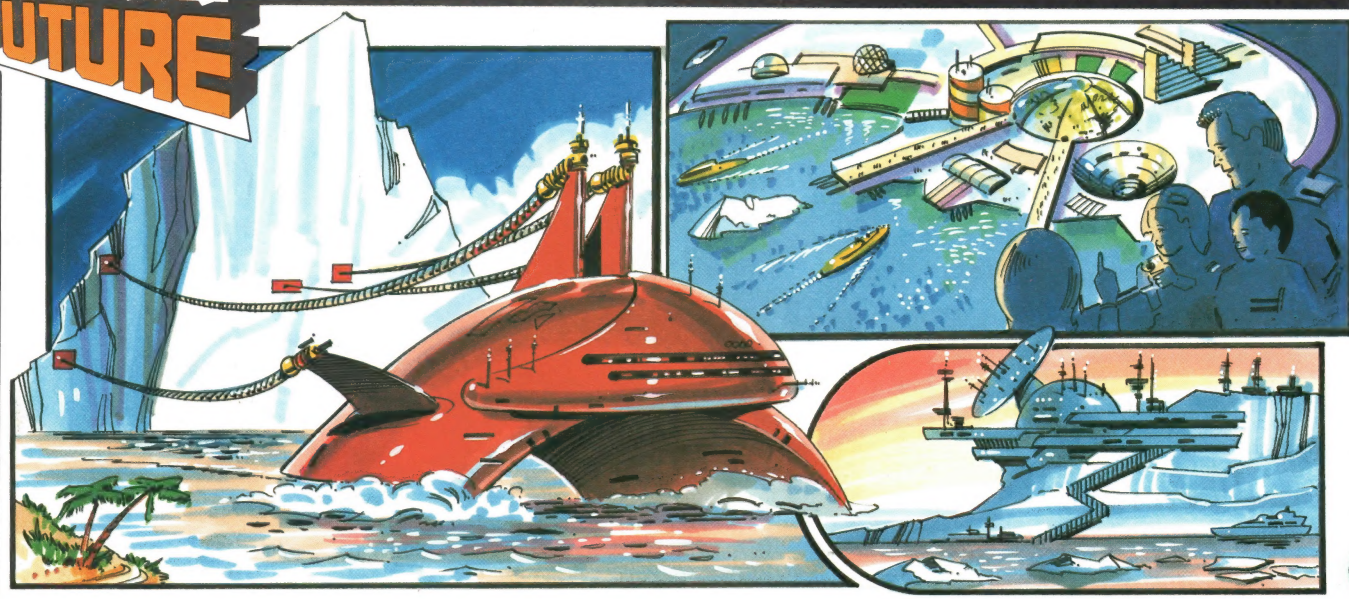
Polar bears

To get from one floe to another, polar bears dive in and swim, paddling with their front legs and using their hind legs as a steering rudder. They can remain in the near-frozen sea for several hours. Their thick, oily fur and a layer of fat ensure that they stay warm.

Boyle/British Antarctic Survey

INTO THE FUTURE

NEW POLAR HORIZONS



▲ *In the next century, icebergs might be towed thousands of kilometres to dry regions where they would be melted down to supply pure water.*

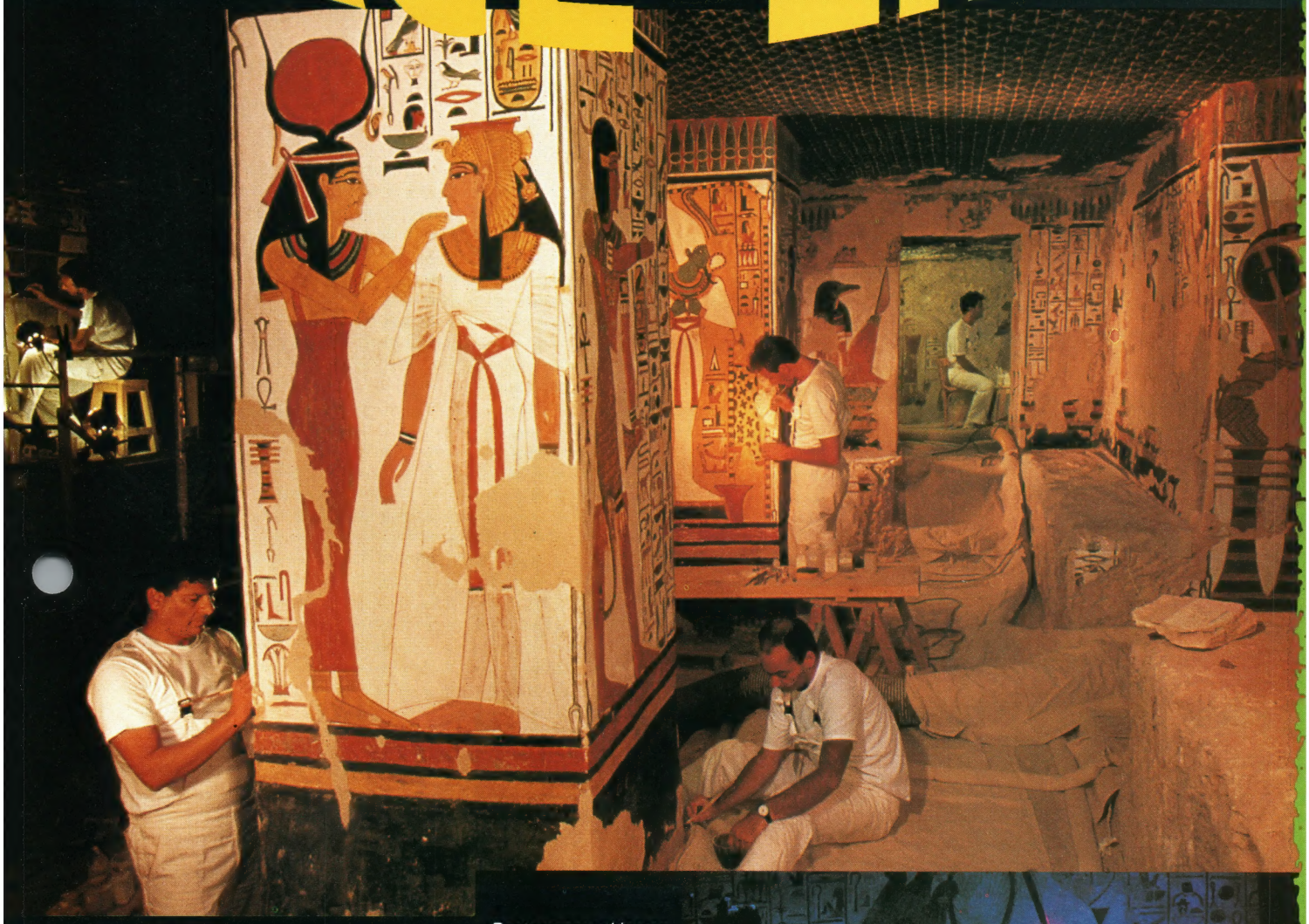
▲ *The Arctic and Antarctic could become booming tourist destinations with hotels located on or below the ice and cruises to see icebergs and marine life.*

▲ *Large scientific stations will be set up in the polar regions to study the vanishing ozone layer and other effects humans have had on the environment.*

Joe Lawrence

Q NEW MATERIALS Q LARGE BREAKS
Q FIRE DAMAGE

FACE-LIFT



Gamma/Frank Spooner Pictures

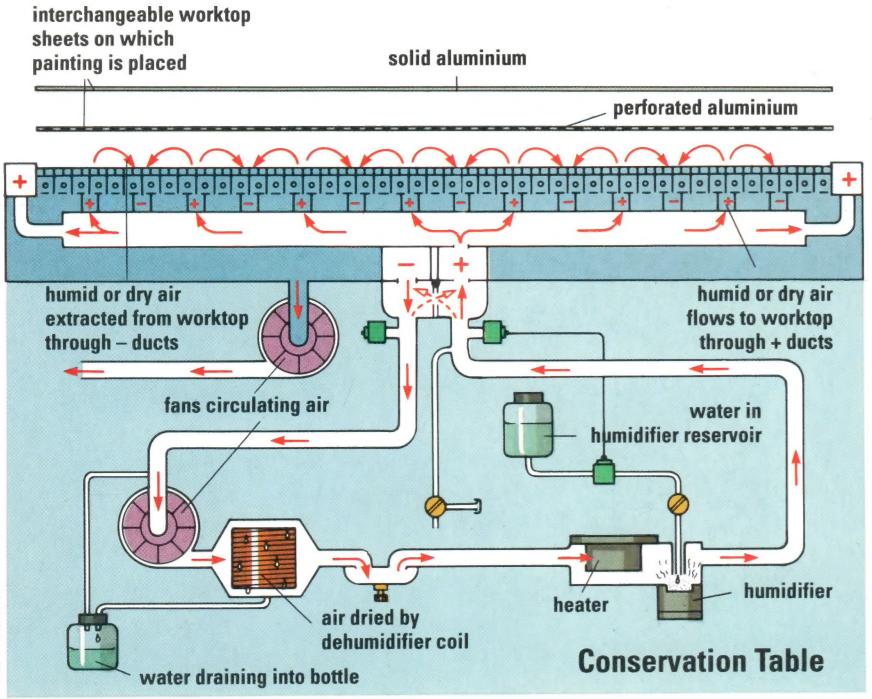
RESTORING A PRICELESS work of art to its original condition calls for more than just immense skill and patience. It involves using the latest developments in high technology, computers and chemical treatments.

First, the restorer seeks to avoid any further damage or deterioration to the artwork, whether it be a painting, a stained glass window, a sculpture, or an entire building. In the next stage, detailed photographs are taken of the object and a thorough analysis carried out of its current state and make-up. Finally, the restorer has to decide what methods to use in the restoration process and then painstakingly apply them.

One of the most remarkable and famous series of paintings in the world

***Restorers** working on over 500 square metres of wall paintings in the tomb of Nefertari, a Queen of Ancient Egypt. A top priority is refixing the painted plaster to the walls with special adhesives. Ultra violet light (right) is used to analyze the structure of the painted surfaces.*

Gamma/Frank Spooner Pictures



Paul Williams

With warm, humid air *circulating around a painting, restorers can apply and remove glue on the canvas back and repair cracking in the paint, before the painting is dried.*

is on the ceiling of the Vatican's Sistine Chapel in Rome, Italy. They were painted by Michelangelo between 1508 and 1512. He painted directly on to wet plaster in a technique called *fresco*, meaning fresh.

Masterpiece revealed

Unfortunately, more than 450 years of Rome's dust, together with sooty grease from burning candle tallow, dulled the masterpiece. Worst of all, generations of earlier restorers tried to brighten the fading pictures with successive layers of varnish made of animal glue. Though this worked temporarily, in the long run each layer of varnish darkened, giving the ceiling paintings an even more dingy appearance than before. As a result, the Vatican decided recently to employ a team of Italian experts to restore the Sistine Chapel ceiling using the most up-to-date methods available.

Before any actual cleaning began, a battery of tests was carried out to reveal the history of the frescoes over the centuries. The main object was to distinguish the original work from that added by later artists and restorers. Infrared light was used to penetrate old varnish and overpainting to show Michelangelo's original fine details. Taken in ultraviolet light, on the other hand, photographs were able to highlight additions and changes.

Minute samples were also taken of the pigment itself. These samples were suspended in a polyester resin, allowed to harden, and cut into cross-sections. Examination under a microscope then revealed the order in which foreign matter, such as later varnish and dirt, was deposited on top of the original painting.

Armed with this knowledge, the restorers began to remove the centuries of grime that coated Michelangelo's work. A sponge was dipped in distilled or de-ionized water and gently wiped over a small section of the fresco. With a natural-bristle brush, a cleaning solution, known as AB57, was then applied. AB57 is made of bicarbonates of sodium and ammonium together with an antibacterial, antifungal agent, mixed in carboxymethylcellulose and water. The result is a gel that, within about three minutes, dissolves the grime and can

Rex Features Ltd

The statue of Christ *overlooking Rio de Janeiro, Brazil, had to be repaired, after the 30-metre-tall statue's soapstone cladding began to crack.*

David Bradfield/National Trust Photographic Library

Uppark House *in southern England was nearly burned to the ground in 1989. As part of the rebuilding programme, some 750,000 fragments of plaster, wood, metal and textiles (left) were recovered and re-used.*

The News, Portsmouth

be removed with sponge and water.

Other restoration work in the Sistine Chapel is concerned with replacing plaster that is loose or has fallen off. During the 18th century, T-shaped bronze clamps were inserted to anchor weaker sections of plaster. Where these cause no problem, they are left as part of the ceiling's history. When clamps are removed, thin pieces of gauze are pasted on to the areas that must be preserved while the background plaster is being delicately chiselled away and replaced.

Data programming

At every stage, a computer is used to record the progress of the restoration. All the results of the photographic survey and laboratory analyses, together with the exact position of cracks, metal clamps, weak areas of plaster, and restored parts can be viewed on a colour graphic display.

When part of a painting or fresco is missing, the restorer can leave the painting as it is, or copy the original artist's style and colour (the usual practice when restoring oil paintings) or paint in the lost area in such a way that it is clearly not part of the original. With fresco restorers, the last option is the most popular.

Some of the best surviving ancient Egyptian frescoes were discovered in the 3,200-year-old tomb of Nefertari, Queen of one of the most famous Pharaohs of Ancient Egypt, Rameses II. But they have deteriorated to the point where portions of plaster have fallen off the rock wall, spoiling the appearance of the paintings.

A team of restorers is now reattaching the painted plaster to the wall and using a technique called *trategio* to replace the lost artwork. The painting is done, not in solid colour, but in tiny parallel strokes of water-colour paint, which can be removed in the future. From a distance, the restored painting blends in well with the original. Closer up, it is obvious which is the repaired section.

Rebuilding

What happens when an entire building of historic importance is badly damaged by storms or fire? This was the problem facing the National Trust in August 1989 when Uppark House (a 200-year-old mansion in Sussex, England) almost burned to the ground. Luckily, the fire left the building's basic structure intact. In addition, firemen and rescue workers managed to save 95 per cent of the house's rare and valuable contents. It was decided, therefore, to try to restore the historic house to its original state.

Four thousand labelled plastic dustbins of debris were sieved for fragments of metal, wood and plaster, which were all tagged, and catalogued on computer disc. These have been used in a rebuilding operation that will go on into the next century.

Plasterwork

One of the finest features of the interior was the plasterwork. Though a few large ceiling sections survived, most of the plaster was in thousands of tiny pieces. These were stored in labelled trays in humidity-controlled sheds (called terrapins) and were reassembled in a huge purpose-built

God's hand *in Michelangelo's painting in the Sistine Chapel was repainted 400 years ago. Recently, surrounding plaster was replaced but the hand was kept.*

A replica *of a painting, one of nine, being moved into position at the Queen's House, Greenwich, London, UK. The original paintings (now elsewhere) were photographed and copies printed out at full size. To fill gaps in the copies, a computer (left) duplicated images from the paintings and 'pasted' them into blank areas.*

The Great Palace *in Pushkin (formerly Tsarskoye Selo) outside Leningrad in the USSR was looted and partially destroyed during World War II. It has since been restored and is now a museum.*

DAMAGED FURNITURE

Rough handling is not the only way in which old furniture can be damaged. Woodworm is one problem: the best treatment is methyl bromide gas, since liquid pesticides can easily ruin lacquered or gilded surfaces. Another major cause of damage is central heating, which reduces the level of moisture in the air. In the past, European furniture was built from timber seasoned so it would last well in a damp, cool climate. Central heating dries out the wood, splitting it and causing veneers to peel. However, humidifiers and air conditioning will keep the atmosphere moist and the temperature down.

hanger.

Small pieces of sculpture or pottery can be glued back together using a very strong polyester resin. Chips are often replaced with solid polyvinyl acetate, which is easily moulded and can be coloured. For larger breaks in a sculpture, such as when a life-size arm is broken in two, dowelling is usually the best answer.

Gamma/Frank Spooner Pictures

National Trust Photographic Library

This stone bust *is being cleaned and repaired by a sculpture conservator. He is gluing chips back into place, over the statue's left eye. The bust is in two parts, which are held together with a dowel (probably made of iron).*

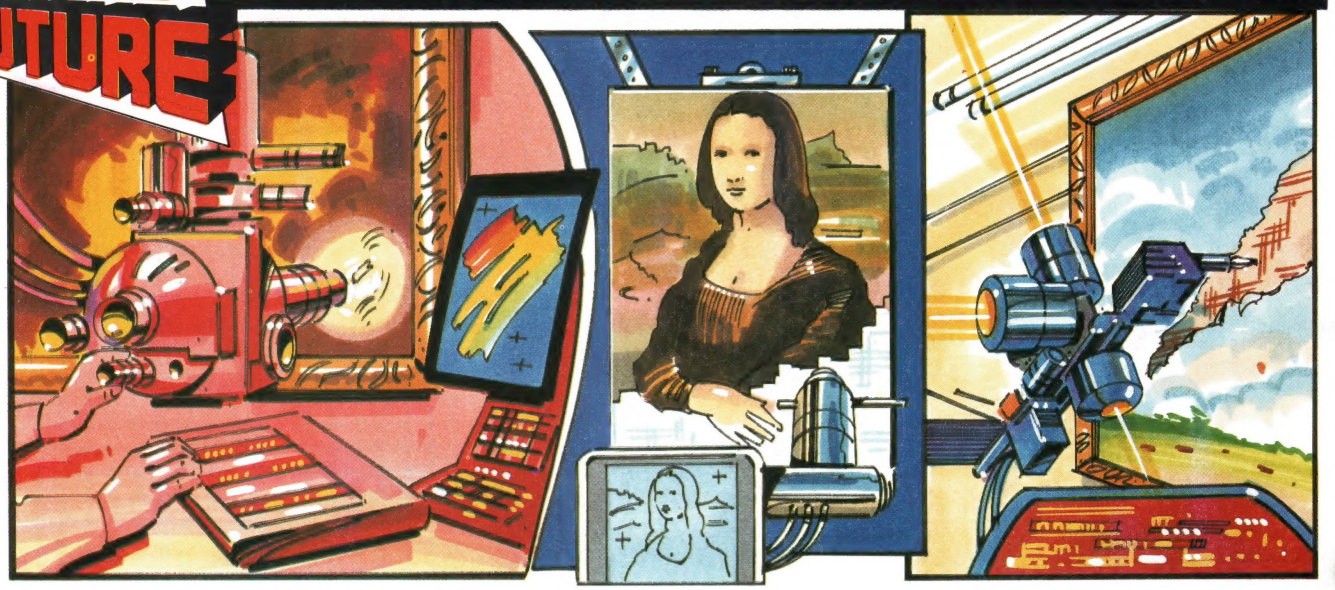
Sculpture

A spot of coloured paint is put on the centre of one half, and the two pieces fitted together. In this way the corresponding point on the other half is marked. Next, a hole about 8 cm deep and 1 cm wide is bored through the centre of each mark. Great care must be taken that the holes are aligned properly. Finally, a stainless-steel dowel is inserted and the two halves are stuck together with adhesive.

Although restoration techniques have come a long way, researchers are still looking for new substances that will last longer and give better results. For example, a new varnish is needed to help protect paintings. Natural resin varnishes, used in the past, begin to deteriorate only 10 years or so after they are applied. The most stable varnish in use today is a synthetic acrylic one, Paraloid B72. It may be more durable, but it fails to match the quality of natural resin varnishes.

INTO THE FUTURE

COMPUTER MASTERCLASS



Joe Lawrence

▲ *By analysing the composition of paint, the brush strokes and the sequence of painting, restorers can work out exactly how a masterpiece was created.*

▲ *After feeding this information into a computer, it would be possible to teach a computer to paint a picture in the style of Leonardo da Vinci, Goya or Rembrandt.*

▲ *Then, damaged masterpieces could be restored by having the computer paint in the missing section – or even create a new masterpiece of its own.*

SOMETHING IN THE AIR

- SMOG
- ACID RAIN
- OZONE

IN FILMS, VICTORIAN London is always depicted shrouded in fog as thick as pea soup. This was 'smog' caused by all the wood and coal burning in the city that disappeared when open fires were outlawed. Yet even though the 'peasoupers' have gone, the air in most cities is still hazardous both to people and to the environment.

In Athens and Los Angeles, it is easy to see the thin smog that hangs over the city. But most of the harmful gases are invisible and have no smell. They come from factories, coal-fired power stations and cars.

Danger gases

In humans, these gases can lead to the development of asthma, bronchitis and brain disease. They are also linked to the wider problems of acid rain, the greenhouse effect and the thinning of the ozone layer.

One of the most dangerous gases polluting our cities is carbon monoxide, the largest source being road vehicles. When inhaled, molecules of carbon monoxide attach themselves to the red blood cells.

Damage and death

They form compounds which prevent the cells from carrying oxygen around the body and effectively kill off the red cells. If too little oxygen reaches the

***Smoke from the chimneys** of coal-fired power stations is one of the main causes of air pollution.*

Tony Stone Photo Library, London

ZEFA

In Los Angeles, *USA, only the tallest buildings are able to stick out above the low-lying smog.*

brain, reflexes and thinking slow down, and even death may result. Those most at risk are people with heart problems, young children and the elderly.

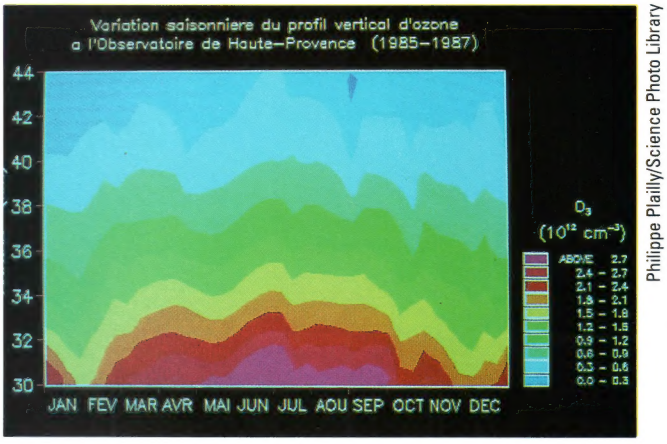
Breathing problems

Most nitrous oxides also come from cars, although power stations are another source. These oxides cause breathing problems. They can aggravate bronchitis and chest infections and can cause acute difficulties for asthma suffers.

High levels of sulphur dioxide can cause restrictions of the bronchi – these are the tiny tubes that carry air

Will McIntyre/Science Photo Library

A computer graph *of the atmosphere above Haute-Provence in France shows the varying levels of ozone at different altitudes. The highest concentration is at the lowest altitude.*



Philippe Plailly/Science Photo Library

A scientist *measures acid rain pollution in a conifer forest. Affected trees are stunted, with yellowing and dropping needles.*

in the lungs. This is particularly dangerous to asthmatics (sulphur dioxide was the cause of most of the deaths during the London fogs). Sulphur dioxide is produced by coal-fired power stations, paper mills, mining and smelting operations, and domestic fires.

Both nitrous oxides and sulphur dioxide have other effects, too. They make acid when dissolved in water and are the major causes of acid rain. Acid rain eats away at the marble, limestone and granite that were used to build our ancient cities.

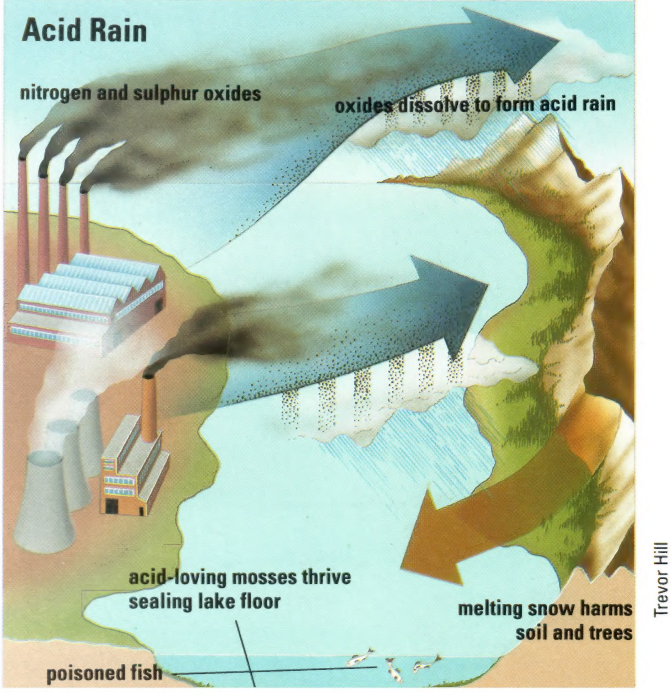
The acid can also be carried a long way in the clouds. The output of British power stations causes acid rain in Scandinavia where the soil has a natural acidity. In southern Norway, 33,000 sq km of lakes have been affected – some 13,000 sq km have no fish life left at all.

'Lichen deserts'

Trout and salmon have been particularly affected, along with mammals that feed on them. Insects and trees have also been badly affected by acid rain. Many forests in northern and central Europe have been killed. The acid attacks their needles. In the early 1990s almost half of Britain was getting more acid fallout than it could cope with. Lichen are particularly vulnerable. Air pollution has caused many 'lichen deserts'.

Most fuels – like petrol or coal – are hydrocarbons, compounds made up of carbon and hydrogen. When they are burnt, they turn into water and carbon dioxide. But if the burning is not complete, hydrocarbons are emitted along with the exhaust gases out of, say, the chimney of a power station or the exhaust of a car. These hydrocarbons form the fine, invisible

Acid rain *is caused by gases from power stations and cars mixing with water vapour in the air. The acidity or alkalinity of rain is measured in pH figures. Normal rain has a pH of 7; below this figure, rain is acid.*



Trevor Hill

Dr Jeremy Burgess/Science Photo Library

A specially tinted *photograph clearly shows the fumes emitted by a car exhaust. In cities, many people – particularly cyclists – are wearing face masks to filter the polluted air (inset).*

Rex Features Ltd

particles in smoke which can cause cancer if inhaled. One hydrocarbon, methane – the gas used for cooking – is also one of the main gases responsible for the greenhouse effect.

Ozone pollution

Another pollutant gas is ozone. High up in the atmosphere ozone protects us from the Sun's harmful rays. But when it is produced at ground level it is dangerous. High concentrations can damage the lungs and harm the body's defences against disease. It also damages plants, particularly when mixed with other gases like sulphur dioxide.

Ozone is produced by electrical equipment and by chemical reactions involving other polluting gases – hydrocarbons and nitrogen oxide – particularly when exposed to strong sunlight. And high ozone levels are not just a problem in towns – they are also found in the countryside when the polluting gases that create ozone have wafted from the cities. European forests have been badly affected in this way: scientists have discovered that ozone in the atmosphere has caused the death of many of the trees.

Lead poisoning

One of the pollutants that comes out of the exhaust pipes of cars has been added deliberately. Small amounts of the heavy metal, lead, have been added to petrol to help engines run more smoothly. It is not burnt or changed chemically in the car's engine, so it is pumped directly out of the exhaust pipe into the air.

Airborne lead, it has been found, affects children's brains, reducing their level of intelligence. Fortunately, lead-free petrol is now widely available and many people have had their cars modified so that they can use it.

Catalytic converter

Using lead-free petrol is one simple way in which people can cut down on the pollution from cars, but it is not the only way. Having a catalytic converter fitted to your car also helps protect the environment.

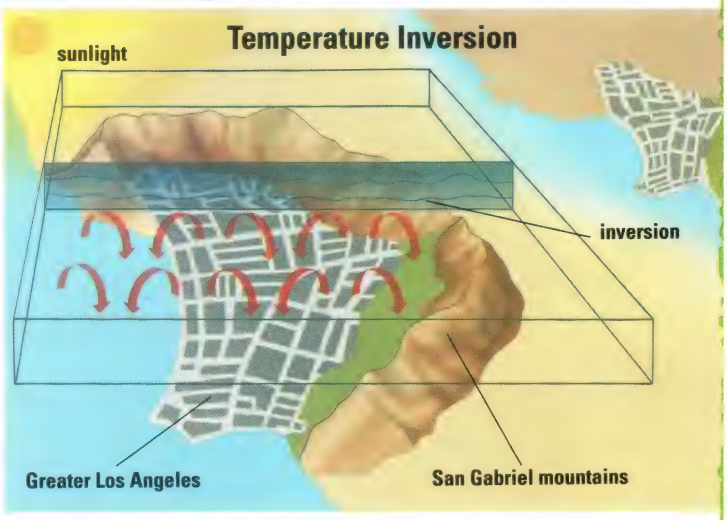
Catalytic converters are boxes which are attached to the exhaust pipes of motor vehicles and are already required by law in some countries. Inside the catalytic converter is a 'honeycomb' made of a ceramic material or metal. The surface area of the honeycomb is huge, roughly equivalent to two football pitches. It is covered with the precious metal, platinum.

Neutralizing pollution

The platinum coating causes a chemical reaction which neutralizes the polluting gases. If the car's engine is badly adjusted and petrol is making its way through into the exhaust without being burnt in the cylinders, the petrol in the exhaust gas will burn up against the platinum, leaving water and carbon dioxide.

On a buoy *off the New York coast, meteorological and oceanographic instruments are used to study air pollution, and the movement of polluting gases.*

US Dept of Energy/Science Photo Library



Trevor Hill

Los Angeles smog *is made worse by the city's geography. The action of the Sun forms particularly harmful gases, and the wind and surrounding mountains cause a 'temperature inversion'. This traps warm air below cold, and polluted air cannot escape.*

NASA/Science Photo Library

***A scientist** on NASA's research craft (inset) uses laser radar to study the 'hole' in the ozone layer, said to have been created by chlorofluorocarbons from aerosols and refrigerators.*

NASA

Carbon monoxide is another gas produced when petrol is not completely burnt. Catalytic converters complete the burning process, turning the carbon monoxide into carbon dioxide.

There are two types of catalytic converter: two-way and three-way. A two-way converter cuts down on the amount of carbon monoxide in the exhaust and completes the combustion of the hydrocarbons, but it does not remove the nitrous oxides. A three-way converter, on the other hand, can turn the nitrous oxides into nitrogen. This cuts the output of toxic gases by about 90 per cent with little effect on fuel efficiency.

One problem with catalytic converters is that they can only be used with lead-free petrol. Another problem is that they do not remove carbon dioxide which passes directly through them – and this is one of the gases producing the greenhouse effect.

Cutting down on cars

Carbon dioxide traps heat from the Sun and excessive amounts of it in the atmosphere could lead to global warming. The only way to check this is to cut down on the number of cars.

But cars are not the only source of pollution. Power stations produce polluting gases too.The fumes leaving the chimneys of power stations contain sulphur dioxide and nitrous oxides. Fortunately, these fumes can be 'cleaned' by means of a Flue Gas Desulphurization Unit, or FGD. This works by trapping the acid-producing fumes in liquid limestone.

Other ways to reduce pollution from power stations is to burn less high-sulphur coal, use nuclear power stations – which have their own problems – or simply use less energy.

Just amazing!

SOMEBODY LOVES YA

ACID RAIN IS NOT ALL BAD. ALTHOUGH STONEWORK SUFFERS WHEN IT FALLS, IT CONTAINS NUTRIENTS, WHICH ENCOURAGE PLANKTON IN THE SEA TO GROW IN ABUNDANCE.

Paul Raymonde

***An aerial view** of Unit 7 of the Heilbronn power station in Germany shows the system used to remove nitrogen oxides from the station's waste gas. Built in 1982 with the environment in mind, the Unit also contains machinery for the removal of sulphur dioxide and dust in the flue gas.*

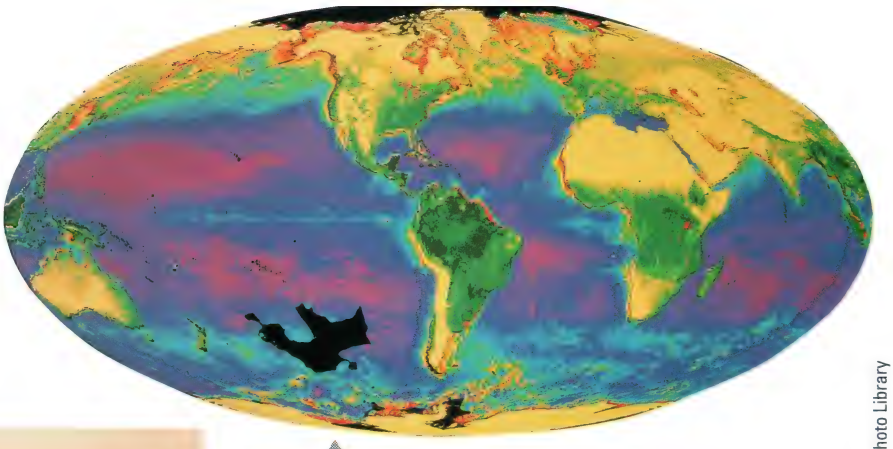
Energie-Versorgung Schwaben AG

They also realized that the atmosphere of the planet seems to be very accurately controlled. If there was just one per cent more oxygen in the atmosphere, the chance of a forest fire being started by a lightning flash would be increased by 70 per cent. That would mean that all the Earth's vegetation would quickly be burnt off and life could become impossible.

The delicately controlled balance of the planet's atmosphere was the first indication that life did not just exist on Earth – it actually controlled the environment. Together, the living creatures and the environment they controlled seemed to form a single living organism.

That is not to say that the whole of the Earth is alive. But a tree, for example, is a living thing though more than 90 per cent of it – the bark and most of the wood – is dead tissue. Only a thin skin surrounding the trunk, directly under the bark, and the twigs and leaves are alive. The Earth can be seen in very much the same way. The core of the planet is dead. There is also dead material above the Earth – the air. In between, there is a thin layer that is alive, where animals and plants live. So, like a tree, the living and dead parts of the Earth could be considered as a single living organism – which scientists named after the Greek Earth goddess Gaia.

Another strange fact that can only be explained by the Gaia theory is the constancy of the temperature of the planet. Although during the past 3.5 billion years the amount of heat generated by the Sun has increased by some 25 per cent, the climate of the Earth has remained practically the same. For that to happen the Earth's temperature must have been regulated by something and, so the argument goes, the only possible medium is living creatures.



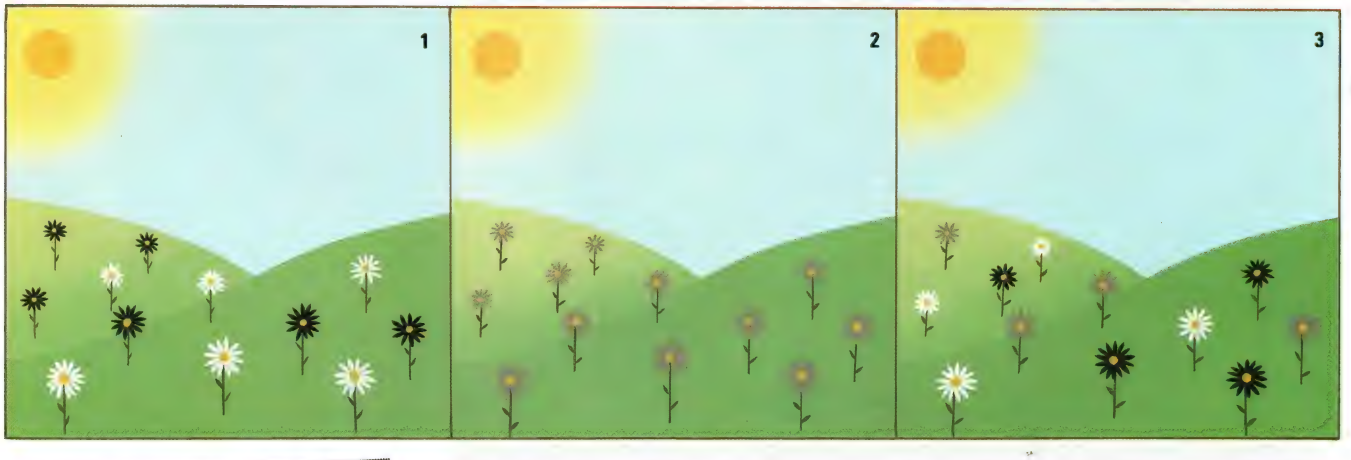
Tony Stone Photo Library, London

Dr Gene Feldman, NASA GSFC/Science Photo Library

The biosphere *shown in a false-colour image. Red shows the densest vegetation, yellow and blue less dense, and pink the sparsest.*

The rainforest *helps regulate the amount of carbon dioxide and water vapour in the air. Cut it down and Gaia may cause a hostile change in the environment.*

TEMPERATURE CONTROL WITH DAISIES



Trevor Hill

A computer-created planet, which can grow only black or white daisies can maintain a constant temperature – around 40° C – even if the Sun is heating up. But the critics asked what happened if there were grey ones. Wouldn't a neutral daisy that did not have to create pigment, either black or white, surely triumph? When the model was modified to contain three types of daisies – black, white and grey – it was found that they regulated the planet's temperature even better. And if there were 20 different coloured daisies, the temperature was kept even more stable, despite the warming of the Sun.

Paul Raymonde

Creature committee

Critics remarked that this phenomenon must be explained in some other way. Surely all the creatures of the Earth could not have got together and formed a committee to decide what temperature the Earth should be! However, if you create a simple computer model of a planet

THE LIVING PLANET

THE EARTH IS A SINGLE living organism – not a collection of rocks and seas with plants and animals living on it. And its name is Gaia.

The idea that planet Earth is alive is probably as old as the human race. Many ancient civilizations thought of the Earth as a living goddess. But the idea achieved a new acceptance with the Space programme when men first saw the Earth from Space. The Earth with its seas and its clouds looked so different from the other, dead, planets.

Tony Stone Photo Library, London

Life on Mars

Then, when Space scientists began to send probes out to other planets – Mars in particular – looking for life, they had to think clearly about how they would recognize something living if they saw it. Life on other planets might be very different from the sort of living things we know on Earth.

There were other problems too. Say you were an alien whose idea of a living thing was an elephant. So you sent off a probe to Earth with instruments that could recognize an elephant. But if it landed in the Antarctic, it would not find any elephants and would report back that there was no life on Earth.

Explosive atmosphere

Some scientists began to realize that one way an alien would be able to tell that there was life on Earth was by analyzing the atmosphere. It contains gases like methane and nitrogen. These gases exist in the atmosphere along with the highly reactive gas oxygen – practically an explosive mixture. If there were no life on Earth these gases would react, form compounds and eventually deplete the atmosphere until it became sterile carbon dioxide like that of the dead planet, Mars.

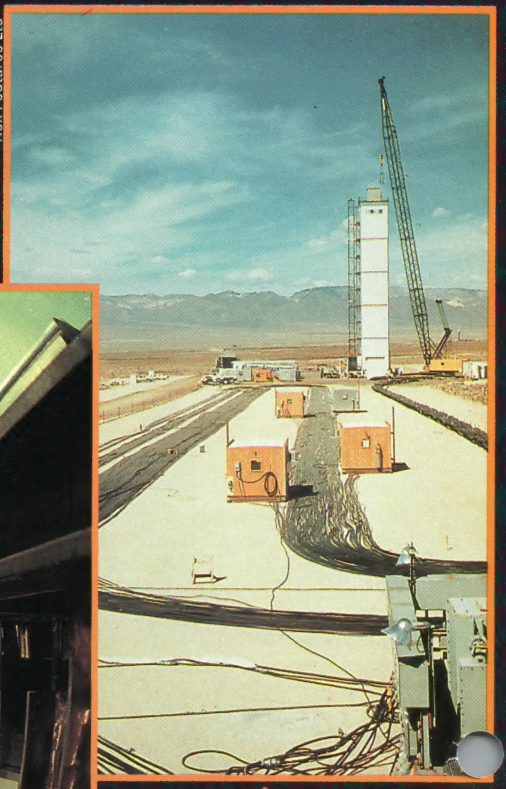
JPL/NASA

***When men** first left the Earth, they noticed that its beautiful blue ball looked almost as if it was alive. An alien would easily be able to see that there was life on this planet from Space without landing on it – just as some scientists say it is possible to tell that the barren surface of Mars (inset) is lifeless without sending a probe there.*

THE HAND OF MAN

ZEFA

Industrial pollution can be deadly. These two scientists have to resort to full protective clothing and breathing apparatus to take a sample of contaminated water.



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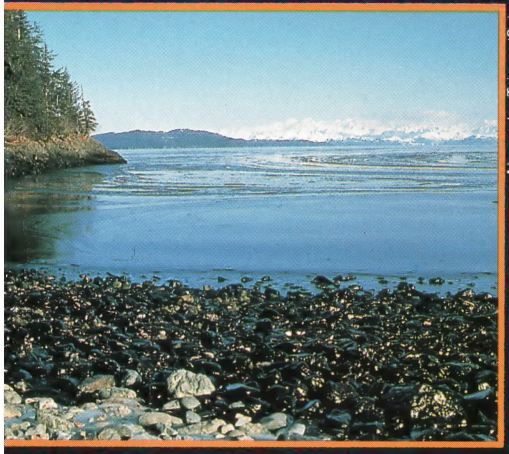
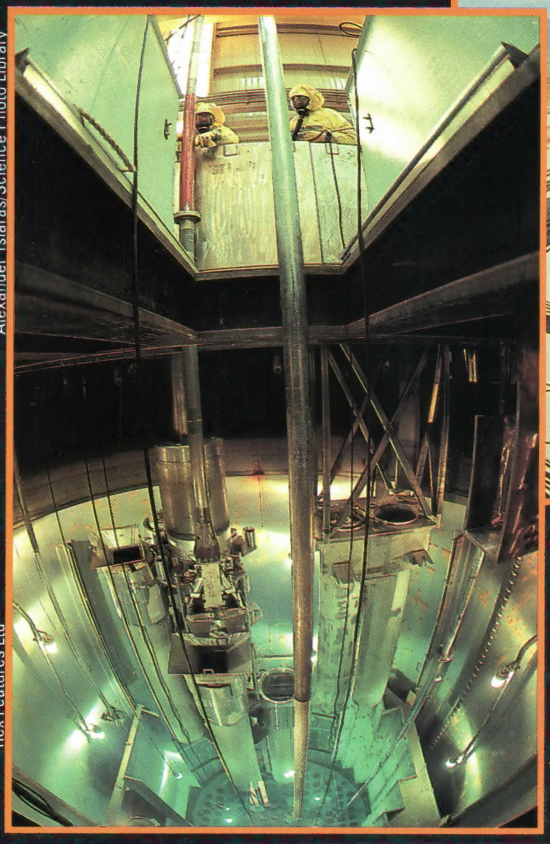
Gamma/Frank Spooner Pictures

Oil washes ashore in Alaska in March 1989, after the Exxon Valdez struck a reef and deposited 11 million tonnes of oil in Prince William Sound.





Alexander Tsiaras/Science Photo Library

Nuclear weapons used to be tested at ground level, or in the air. This threw enormous amounts of radioactive dust up into the atmosphere. Now they are tested underground.

Engineers practise emergency procedures at Three Mile Island. The clean-up after an accident in 1979 will be completed in 2019.

Rex Features Ltd

Raw pollution is pumped into a river in the Czech Republic. It will flow into other countries.

Peter Parks/Oxford Scientific Films

Can carriers can get around the necks of sea birds and strangle them as they grow.

Mercury used in gold extraction in South America washes into a stream, poisoning it.

Crop spraying in the Napa Valley in California causes atmospheric pollution and contaminates the surrounding area.

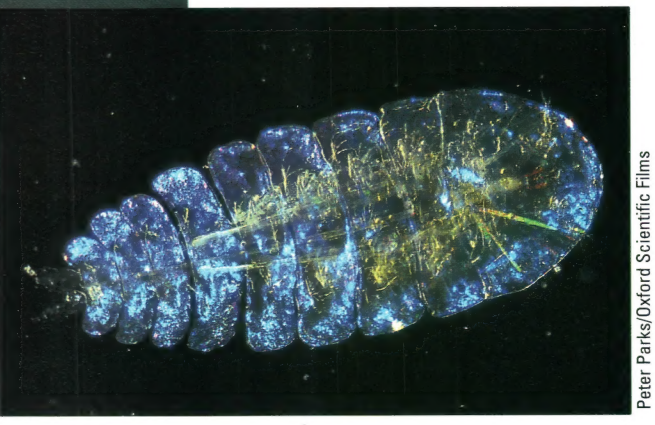
Hutchison Library

Tony Stone Photo Library, London

clouds. The shadow of the cloud cools a patch of the ocean, allowing the surface layers to mix with the cooler layers below. The clouds give rise to storms which also help mix up the water, and the micro-organisms get the nutrients they require. White clouds also very effectively reflect heat from the Sun back out into Space, cooling the planet.

Salt control

The seas are made salty by the minerals washed down by the rivers and those brought up by volcanic activity in the bed of the oceans. But without some living regulator this mechanism would simply have made



Peter Parks/Oxford Scientific Films

***Chalk cliffs** represent massive amounts of carbon dioxide taken out of the atmosphere by tiny shellfish (right). They used carbon dioxide to make their shells which, in turn, make chalk.*

that can grow only white daisies or black daisies, it turns out that they will regulate the temperature easily. If the temperature is low, the black daisies flourish because they absorb sunlight better. But by flourishing and absorbing heat, they raise the temperature of the planet. This allows the white daisies to compete. As the white daisies multiply, they reflect heat, lowering the temperature of the planet – providing a self-regulating system.

More species

The beauty of this computer model is that it works just as well if you introduce rabbits and foxes that feed on the rabbits. In fact, the more species there are the more stable the climate.

In the real world, the climate is controlled by tiny creatures in the seas. The seas are dark blue and absorb heat easily. The heat in turn warms the surface of the oceans.

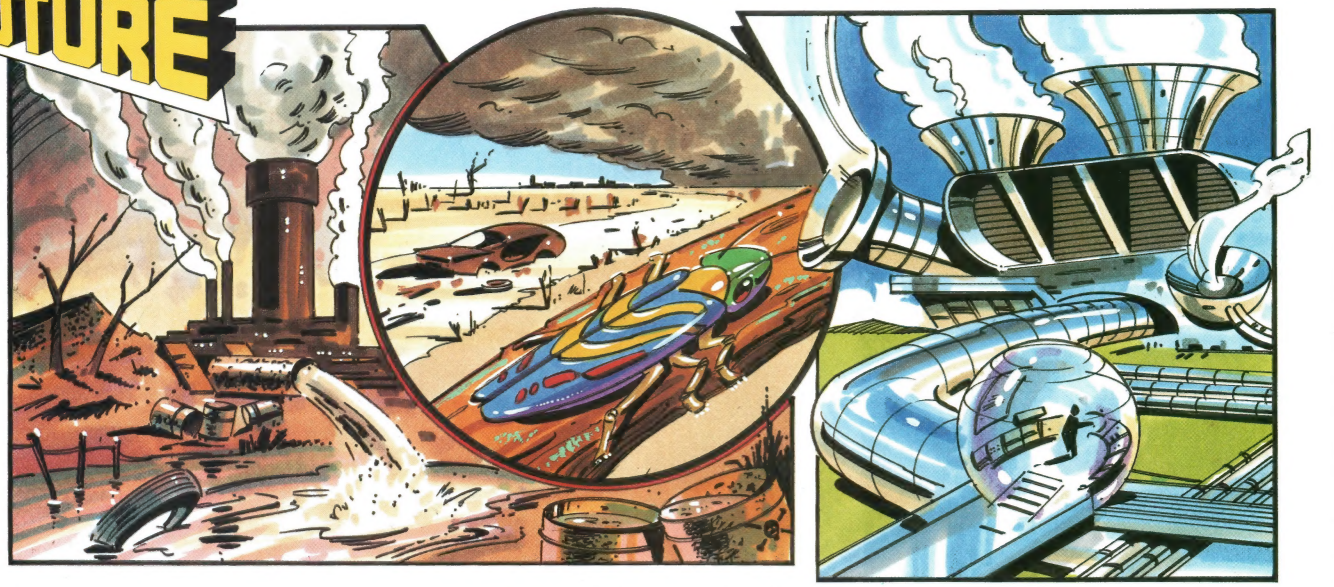
However, when the surface of water gets warm, the tiny creatures that live there are starved of the nutrients that live at lower, cooler levels. So the hungry creatures release gases that begin the formation of

the sea more and more salty. Life can only exist in the seas at a level of salinity below 6 per cent and micro-organisms have maintained that level since the seas began.

These same micro-organisms maintain the appropriate level of chlorine in the atmosphere, while small marine crustaceans regulate the greenhouse gas, carbon dioxide.

INTO THE FUTURE

THE GAIA FACTORY



Joe Lawrence

▲ *The Gaia theory says that any species that does not aid the planet as a whole quickly perishes, though Gaia herself will continue.*

▲ *If mankind succeeds in throwing the planet out of balance, the environment will change, making human life impossible, though other creatures would survive.*

▲ *However, it may just be possible to create a Gaia factory that would cleanse the atmosphere, rebuild the ozone layer and maintain a favourable temperature.*

- FOOD CHAINS
- PITCHER PLANTS
- TOP PREDATORS

WORLDS WITHIN WORLDS

ALL LIVING THINGS ARE inter-dependent. They inter-react with each other and with their environment, both on a small scale and on a large scale – from a rotting branch to the planet-wide biosphere. These spheres of interdependence are called ecosystems.

Food, in some form, is needed by every living creature, to grow, reproduce and repair itself. Green plants can make their own food by taking in very simple substances together with energy from the Sun.

Rotting bodies

Some animals – herbivores – eat green plants as a source of ready-made food, while others – carnivores – feed on the plant-eaters or smaller meat-eaters. And when both predators and prey die, their rotting bodies provide nourishment for plants and microscopic life-forms so that the cycle can continue. Such a food chain lies at the heart of every ecosystem.

Richard Kirby/Oxford Scientific Films

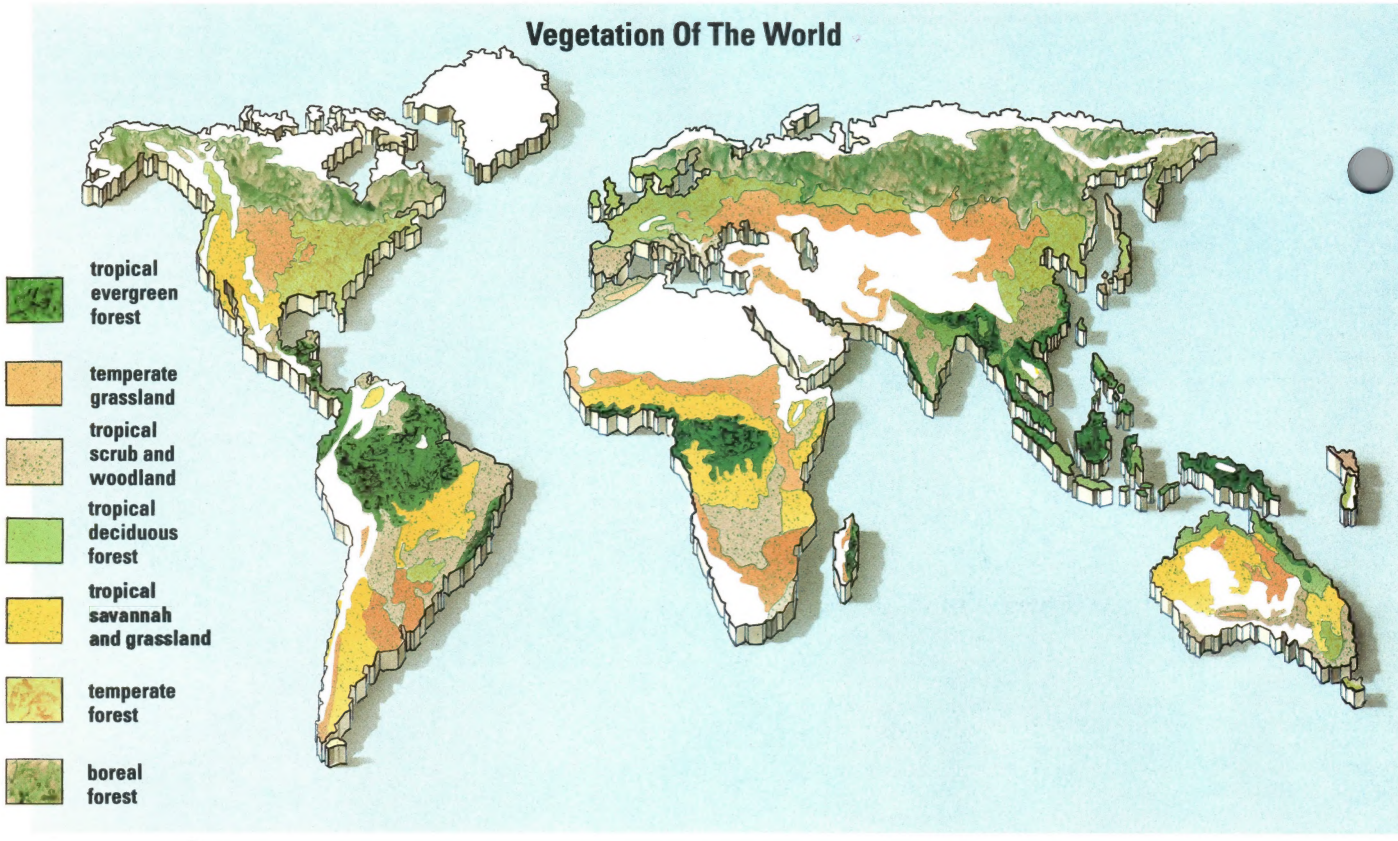
Doug Allan/OSF

***Lake Baikal** in Siberia contains about one-fifth of the world's fresh water. Despite its size, it is a unique ecosystem. More than 1,000 of the species that live there, live nowhere else on Earth. The lake's top predator is the Baikal seal (left).*

Among the smallest and most unusual ecosystems are the water-filled traps of pitcher plants. Like the Venus flytrap, pitchers tend to grow in poor soil where few other plants can survive. To make up for the lack of nutrients in the soil, they catch small insects in trumpet-shaped leaves that hold special digestive juices, diluted with rainwater, to form a small pool.

Lured by nectar at the rim of the pitcher, a variety of flies and other insects tumble down the steep sides of the leaves into the pool at the bottom. But as the victim's bodies are broken down, they supply food not only to the pitcher but also to a community of tiny creatures that live inside it. Swimming around in the pitcher pool are the larvae of biting midges and mosquitoes, together with small mites. These, in turn, are the prey of hoverfly larvae that lurk close to the water on the sides of the pitcher.

Tree stumps and broken bamboo stems, in the tropics, also collect rain water that supports communities of



Simon Critchley

***The major vegetation belts** are huge ecological communities of plants and animals. Particular species are confined to areas called biomes. These vegetation belts or biomes are limited by rainfall, soil type and mountains.*

various larvae, snails and free-swimming crustacea similar to shrimps. Heading these miniature food chains is sometimes a 'top' predator — a single dragonfly nymph that hides deep in the pool ready to feed on anything it can creep up on. These top predators are like the lion, eagles and sharks of large ecosystems on the planet.

Self-contained ecosystems, such as pools in plants, give scientists the chance to work out in detail the way energy enters the system and the way species depend on one another. On a huge scale, Lake Baikal in Siberia offers the same opportunity.

With an age of 20 to 25 million years and a depth of 1,637 metres, Lake Baikal is the oldest and deepest lake in the world. It also contains the most species. Of the 1,550 different types of animals and 1,085 varieties of plant that live there, more than 1,000 occur nowhere else on Earth.

Sunlight falling on Baikal promotes the growth of phytoplankton — tiny, single-celled plants — which microscopic animals, or zooplankton, feed on. Both types of plankton are eaten by numerous types of small animals, such as the lake's many species of shrimp. The shrimp and small fish become food for bigger fish, which in turn are eaten by the lake's largest predator, the unique Baikal seal.

An ecosystem such as that of Baikal can be easily upset, however. This was demonstrated in the 1960s when a shrimp-like amphipod was introduced into California's Lake Tahoe. The idea was to provide extra food to boost Tahoe's trout and salmon population. But the experiment backfired. Instead, the new amphipod wiped out two of the lake's native species of zooplankton, cutting the fishes' food sources rather than enhancing it.

Keith Scholey/Planet Earth Pictures

Peter Parks/OSF

***Tiny ecosystems** form in pools in plants. The pitcher plant contains a whole community of creatures who live on the victims that the plant catches. This fly (left) was lured by the plant's nectar. It fell down the steep sides of the pitcher to provide a solid meal for the plant and the larvae that live in it.*

Just amazing!

THE COSMIC CULL

ABOUT 65 MILLION YEARS AGO, OVER TWO-THIRDS OF ALL THE SPECIES ON EARTH BECAME EXTINCT. THE CAUSE MAY HAVE BEEN A COLLISION WITH A TWO-KILOMETRE-WIDE ASTEROID.

Paul Raymonde